Volume 60 Article 8

1-1-1973

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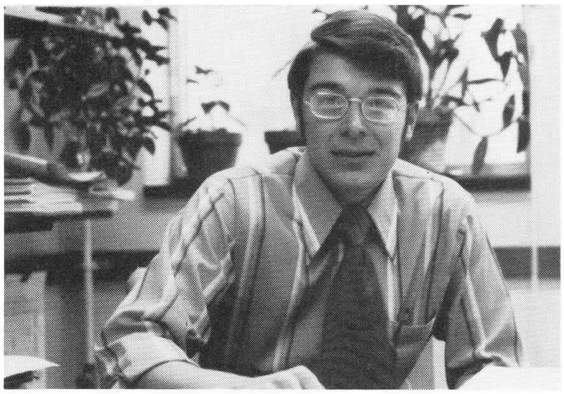

The photosynthetic process is essential to life. Not only are the carbon skeletons that form the structural basis for plants and animals synthesized during photosynthesis, but the energy needed for their maintenance and increase is captured in useable forms from sunlight. Consequently, the photosynthetic process has received unrivaled attention by plant physiologists.

Recent discoveries in photosynthetic research have revealed that not all plants photosynthesize by the same physiological mechanism. Calvin plants, named after the Nobel laureate who elucidated their physiology, are considered less efficient photosynthetically than Hatch-Slack plants, named after the two Australian scientists who discovered them. Most plant species are Calvin plants, but a number of important plants, such as corn, sorghum, sugar cane, pigweed, and crabgrass, fall into the more efficient Hatch-Slack group. Hatch-Slack plants appear to be adapted to more tropical environments where extremes of light, temperature, and aridity prevail and are generally considered more productive.

What about trees and other woody plants- Tree physiology research had not clearly established whether trees were Calvin or Hatch-Slack by nature. Early last summer Dean Gjerstad, a graduate student in forest biology, and I set out to provide a clearer answer to this question.

METHOD OF STUDY

When a leaf or twig is placed in a closed environment in the light, its photosynthesizing tissue will extract carbon dioxide from the air until the rate of photosynthesis and the rate of respiration, a process that releases carbon dioxide, are in equilibrium. This equilibrium level is known as the carbon dioxide compensation point.

For Calvin plants the compensation point usually falls between 50 and 60 parts-per-million (ppm) carbon dioxide. That is, when the carbon dioxide concentration reaches this level, the leaf cannot photosynthetically extract any more carbon dioxide from the air due to the compensatory release of carbon dioxide by respiration. The efficiency of Hatch-Slack plants is revealed by the fact that their compensation point is near zero. In other words, they can photosynthetically capture all carbon dioxide from a closed environment, plus any that is being released by respiration. Thus, determining the compensation point of a leaf gives a direct clue to its photosynthetic physiology.

In our study Dean and I used a simple yet accurate technique for determining compensation points. A leaf or twig was sealed in a plastic bag, the bag inflated with air, and after one hour in the light the carbon dioxide level of the air in the bag determined with an infrared gas analyzer. Due to the amazing diversity of tree and woody plant species growing on the Iowa State University campus, we were able to measure compensation points of 69 different species and hybrids, representing virtually the entire taxonomic spectrum of woody plants.

RESULTS OF THE STUDY

The table summarizes the results of our study. Every species and hybird measured had a carbon dioxide compensation point that fell in the range associated with the photosynthetically less efficient Calvin plants. However, these results do not preclude the existence of a Hatch-Slack woody plant, since we could not measure every tree species. In our attempts to increase forest productivity the search for a more efficient, productive Hatch-Slack tree should continue. The development of an intensive silvicultural system around such a tree, if found, promises to significantly increase production of wood fiber.

TABLE 1. Carbon dioxide compensation points of 69 woody species and hybrids.

Taxonomic group	Compensation Points ($ppm\ CO_2$) Mean	Range
14 Conifers	62	52–72
39 Hardwoods	60	49–71
16 Poplar hybrids	58	50–68